THE ECONOMICS OF HEATING A HOUSE

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The Montana Department of Natural Resources and Conservation (DNRC) has analyzed a hypothetical house to determine the cost-effectiveness of building with different levels of insulation, and with different space heating and water heating systems. This paper, which discusses the results of that analysis, was written at the request of the Montana Building Industry Association (MBIA).

Background

On February 27 and 28, 1990, builders from around Montana met in Helena with representatives of the Montana Power Company and DNRC to discuss the economics of determining appropriate levels of insulation for houses built in this state.

DNRC representatives discussed the results of their analyses of over 100 houses built in Montana to the Northwest Power Planning Council's Model Conservation Standards (MCS). Those analyses have: 1) determined the cost of building houses to the MCS standards in Montana, 2) found that the MCS package of energy-conserving items is cost-effective for electrically-heated houses in Montana, and 3) determined the benefit to a Montana homebuyer who purchases a house built to the MCS rather than to the HUD standards of energy efficiency.

The forum participants focused on DNRC's component cost findings. These findings were compiled from reports made by builders who participated in the 1984 Residential Standards Demonstration Program (RSDP), and the 1987 and 1988 Residential Construction Demonstration Program (RCDP). Builders at the forum reached a consensus as to the current cost of purchasing and installing each building component. Table 1 shows what is generally considered to be the HUD and MCS requirements for each component of a house built in a Zone 3 climate, which covers most of Montana. This table also shows the cost assigned to each component by the builders at the forum. The costs listed are the "incremental costs" incurred in going from the HUD level to the MCS level and are in dollars per square foot of component area. The component costs shown in Table 1 DO NOT include the builder's overhead and profit margin which builders at the forum agreed is approximately 15 percent.

The Prototype house

Discussion at the forum had focused on electrically-heated houses; however, builders felt that they needed information on other heating systems to present to future clients. Accordingly, the MBIA builders asked DNRC to analyze a hypothetical prototype

Table 1.

Incremental Cost

Component	HUD Level	MCS Level	Incremental Cost
ilings	R-38 Conv.Truss	R-49 EnergyTruss	$0.45/Sq.Ft.
ls	R-19, 2x6 studs @ 16", no foam	R-26, 2X6 studs @ 24", 1" foam	$0.59/Sq.Ft.
oors Above awlspaces	R-19	R-30	$0.23/Sq.Ft.
sement Walls	R-11	R-19	$0.20/Sq.Ft.
ndows	Dbl. Glazed	Dbl.Glazed Low-E	$1.25/Sq.Ft.
-Vapor Barrier	Walls Only	Wall-Ceiling-Flr	$0.12/Sq.Ft.
h. Ventilation	None Required	Fans & Intakes	$750 Total

house with guidelines specified as follows: 1) The prototype would be a 2,400 square foot split-level house located in Helena and would have 240 square feet of windows divided equally among the four walls. 2) The estimated incremental cost of raising any component from the HUD level to the MCS level would be determined by prices agreed upon by the builders at the forum. 3) A 15 percent addition to the total incremental cost would be made to account for builders' overhead and profit. 4) A 15-year duration of ownership would be assumed in the economic analysis. And lastly, 5) The additional components installed over the Base Case all-electric HUD house would have a resale value of 70 percent of their original cost; it should be noted that DNRC considers this to be a conservative assumption. All other assumptions would be the same as those made in DNRC's previous studies.

Using the characteristics of the prototype house, DNRC would analyze the economics of both the HUD and MCS levels of insulation in conjunction with gas, propane, and electric heating systems. The heating systems analyzed would be electric-resistance-baseboard, and gas furnaces at two efficiency levels--70 percent and 96 percent. All heating systems would be sized at 150 percent of the design heating load calculated for

the particular variation of the prototype house; Super Good Cents requires that the heating system be capable of putting out 50 percent more heat than required to heat the house on the coldest day of the year. And finally, DNRC would analyze one case where a $1,500 incentive would be applied against the cost of an electrically-heated MCS version.

Economics

The results of studies of this type are typically represented by assigning a dollar value to the various cases being considered. Two common types of economic analysis are "Life Cycle Cost Analysis" and "Net Present Value Analysis." The **Life Cycle Cost Analysis** tells the reader the amount of money that must be put aside today to cover all initial and future costs associated with an action, while the **Net Present Value (NPV) Analysis** is used to compare two choices for the purpose of determining the added benefit today of making one choice over another. Wattsun, a computer program used by Montana utilities to qualify houses for the Super Good Cents incentive program, can provide the Life Cycle Cost of a given house. DNRC, on the other hand, has always discussed the benefits associated with residential energy conservation in terms of Net Present Value in order to best represent the long-term value of making one choice over another.

The Study

The analysis performed for this study compared the costs and benefits of a Base Case house to the costs and benefits associated with houses utilizing 15 different combinations of insulation level, space heating system, water heating system, and heating fuel type. The study included the water heating system because the cost of heating water is a major portion of the utility bill. **The Base Case house was assumed to use electricity for space heating and water heating, and to be insulated according to the HUD standards.**

The costs included in the analysis were those that would be incurred in: 1) purchasing increased levels of insulation and more costly heating systems, 2) additional down payment, closing costs, and monthly loan payments required to cover the cost of the additional components, 3) maintaining the various components in the house (which includes all items not found in the Base Case all-electric HUD house), and 4) additional property tax and house insurance costs resulting from the higher property value.

The benefits included in the analysis were those that a homebuyer would experience in: 1) reduced space heating costs, 2) reduced water heating costs, 3) tax savings due to increased

mortgage interest payments, and 4) recovered cost of the additional components at resale. It should again be noted that the study assumes recovery at resale of only 70 percent of the cost of the additional components used over the all-electric Base Case HUD house.

The effects of the different levels of insulation on the design heating load of the prototype house were determined by running SUNHOUSE, a well-proven computer model. The Net Present Value of the benefit to the consumer was determined by using DNRC's NPV computer model. This NPV model takes into account all of the economic effects of a decision. The assumption used in the model was that a lower-end or first-time homebuyer would secure an FHA loan with a mortgage rate of 9.9 percent, downpayment of 5 percent, and closing costs of 2 percent. Natural gas and electricity rates used in the study were DNRC's estimates based on the Montana Power Company's forecast for future rate increases. The propane price used in the model was $0.75 per gallon; this price was based on quotes obtained from 17 dealers statewide and has been adjusted to account for the price volatility of the past winter. The study assumed that fuel prices would increase at a rate one percent greater than inflation. All assumptions were reviewed and agreed to by the MBIA builders at the forum.

The Results

Listed in Table 2 are the results of the study. Each of the 15 combinations of utility-bill-reducing components is tabulated. The combination number is listed on the far left, and the type of space heating, the level of insulation, and the type of water heating used in each combination are shown in the three columns to the right of the number. The "HUD+" level of insulation is defined as a standard HUD house with double glazed Low-E windows added; this is an increasingly common combination in Montana. Column A shows the total estimated first year utility bill for each combination. This estimated first year utility bill provides a means to calculate the savings that are associated with each of the combinations considered; it is not a predictor of actual utility bills. Column B shows the approximate first year savings in energy costs over the Base Case all-electric HUD house. Column C shows the cost of all components included in the combination less the cost of similar components that would be used in the Base Case all-electric HUD house. Column D shows the Net Present Value (NPV), or benefit, to the homebuyer who chooses one of the 15 combinations over the Base Case all-electric HUD house. DNRC suggests that NPV provides the best guide to

Table 2.

HOW THEY COMPARE

No.	SPACE HEAT	INSUL LEVEL	HOT WATER	A: TOTAL ESTIMATED 1st YEAR UTILITY COST $	B: SAVINGS (1st Year) ON TOTAL UTILITY BILL OVER EL-HUD $/yr	C: COST OF ITEMS OVER ELEC-HUD $	D: NPV (Benefit) TO BUYER OVER ELEC-HUD $	E: RANK OVERALL
BASE	ELEC BASBRD	HUD	ELEC	1580	0	0	0	BASE
1-	ELEC BASBRD	HUD+	ELEC	1495	85	300	700	11
2-	ELEC BASBRD	MCS	ELEC	1340	240	3125	575	13
3-	ELEC BASBRD	MCS w/ $1500*	ELEC	1340	240	1625	1850	7
4-	GAS 70%	HUD	GAS	825	755	3825	5900	3
5-	GAS 70%	HUD+	GAS	795	785	4175	5900	4
6-	GAS 70%	MCS	GAS	745	835	6950	4650	6
7-	GAS 96%	HUD	GAS	755	825	4600	6175	1
8-	GAS 96%	HUD+	GAS	735	845	4950	6100	2
9-	GAS 96%	MCS	GAS	695	885	7700	4725	5
10-	PROPANE 70%	HUD	PROPANE	1305	275	4050	300	14
11-	PROPANE 70%	HUD+	PROPANE	1245	335	4375	650	12
12-	PROPANE 70%	MCS	PROPANE	1140	440	7175	75	15
13-	PROPANE 96%	HUD	PROPANE	1155	425	4825	1475	9
14-	PROPANE 96%	HUD+	PROPANE	1110	470	5175	1650	8
15-	PROPANE 96%	MCS	PROPANE	1030	550	7925	825	10

* Super Good Cents incentive of $1500 included in this case.

Notes:

1) Other estimated 1st Year Costs: appliances & lighting @ $375/yr, electric water heating @ $325 to $335/yr, gas water heating @ $160 to $170/yr, and propane water heating @ $330 to $345/yr. MCS houses are assumed to have hot water tank wraps.
2) Energy conserving houses use less fuel so monthly service charges drive up their effective cost per unit of fuel.
3) Energy costs include seasonal price variations, service charges, and propane storage tank leasing charges.
4) Heating systems have been sized for the particular house's design heating load.
5) HUD+ is defined as a standard HUD house with double glazed Low-E windows added.
6) The prototype house, a 2400 SF split level with 60 SF of windows in each direction, is assumed to be located in Helena.
7) Utility costs are rounded to the nearest $5, NPV's and component costs are rounded to the nearest $25.

selecting insulation level and heating system type because it makes a long-term comparison of each combination to the Base Case all-electric HUD house. Finally, column E shows the overall ranking of each combination of this prototype house.

Observations

Knowing what we know today, natural gas is the low-cost fuel of choice for residential heating. Given current price projections, this fuel cannot be beaten for its ability to save home owners' money. Further examination of Table 2 shows that the natural gas-heated houses providing the largest benefit to the homebuyer are all HUD or HUD+. The additional $3,125 that it would cost to install the complete MCS package of components in the prototype gas-heated houses now appears to reduce the benefit, or NPV, to the homebuyer. However, the homebuyer who decides to purchase HUD levels of insulation in preference to MCS levels is betting that current price and availability projections for natural gas are correct.

Combination number 1, the all-electric HUD+ house, demonstrates the value of Low-E windows. Although its $700 benefit is respectable, the first year utility bill savings is only $85 over the Base Case house. Combination number 2, the all-electric MCS house, provides about the same benefit at $575, but saves $240 on the first year utility bill and, as a result, better protects the homebuyer from unanticipated electricity rate hikes.

The $1,500 Super Good Cents incentive payment, which was applied to combination number 3, results in an NPV of $1,850 and a 7th place ranking. Not one of the propane-heated houses outperforms this combination. The increase in the NPV of combination number 3 over the NPV of combination number 2 is $1,275 ($1,850 - $575). The $1,500 incentive raises the benefit less than one might anticipate because of differences in the tax benefits and closing costs associated with each case. While the incentive payment received in combination number 3 reduces the closing costs, the larger loan in combination number 2 generates additional mortgage interest tax deductions not available in combination number 3; the net effect is that the difference between these two NPV's becomes $1,275. The all-electric MCS combinations, with or without the incentive, provide a substantial benefit over the Base Case all-electric HUD house while at the same time affording protection from future rate increases.

Propane heating systems provide the greatest benefit when a 96 percent efficient furnace is used, as in combination numbers 13, 14, and 15. Seventy percent efficient propane furnaces do not provide as great a benefit to the homebuyer. Combination

number 12, a 70 percent efficient propane furnace paired with an MCS level of insulation, provides the least benefit to the buyer. As with combination numbers 6, 9, and 15, which also have MCS levels of insulation matched with non-electric heating systems, combination number 12 is a weaker performer than its less expensive HUD counterparts. Although MCS insulation levels provide fuel savings over HUD insulation levels, these savings in non-electrically-heated houses cannot offset the increased cost of MCS components. As a result, the MCS combinations with non-electric-heating systems do not provide as great a benefit to the consumer. Propane however, one of the two non-electric heating fuels, can be quite volatile in price. During the winter of 1989-1990, the price of propane rose as much as 70 percent above autumn's price before retreating. A homebuyer seeking protection from the vagaries of propane pricing may choose to spend the extra money for MCS features.

In all combinations, natural gas or propane water heaters provided a greater benefit to the homebuyer than an electric water heater. All water heaters in the MCS combinations were assumed to have a tank wrap that provided some further fuel savings. It should be noted that the fuel cost for propane water heating is slightly greater than the fuel cost for electric water heating. Propane water heating still provides a greater benefit to the consumer because of the economics associated with leasing a propane storage tank. If propane space heating is combined with electric water heating rather than propane water heating, fewer gallons of propane will be used; the cost of leasing the propane storage tank must, therefore, be spread across fewer gallons of propane. The resulting increase in the cost of propane used for space heating more than offsets the combined savings from: 1) reduced water heating cost, 2) savings from not having to purchase the more expensive propane water heater, and 3) savings from avoiding the additional installation costs associated with propane water heaters.

This study also assumed that the cost of the MCS combinations would include $750 for a mechanical ventilation system, while non-MCS combinations would not. Increasing concern about indoor air pollution and builders' liability could lead the market or regulators to require that all new houses have mechanical ventilation systems. Were this to happen, the MCS houses would be more competitive with the non-MCS combinations.

Summary

When builders and homebuyers begin the process of selecting a heating system and level of insulation for a house, DNRC suggests that they consider the up-front cost of the components to be used as well as the ability of the chosen components to provide protection from unforseen future increases in the cost of

energy. Occupant comfort and the reduced interior noise levels found in MCS houses should also be considered when deciding whether the additional cost of the MCS measures are justified.

The results of this study show the approximate heating fuel savings that a home owner matching the study's assumptions would experience. Individuals who run more appliances, have children in and out constantly, or set their thermostats higher, will use more energy than is predicted by these computer models. Even so, investment in extra conservation measures will have much the same net benefit as has been found in this study for houses of this type. The behavior of a house's occupants greatly affects the total fuel bill, but it has much less effect on the relative benefits of a more efficient house compared to a less efficient house. These methods may not predict actual fuel bills, but they do provide a realistic approximation of what the actual heating fuel savings will be and what the return is for making one choice over another; this is something you can count on.